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# Silicon-Bilayer Resists for EUV Lithography

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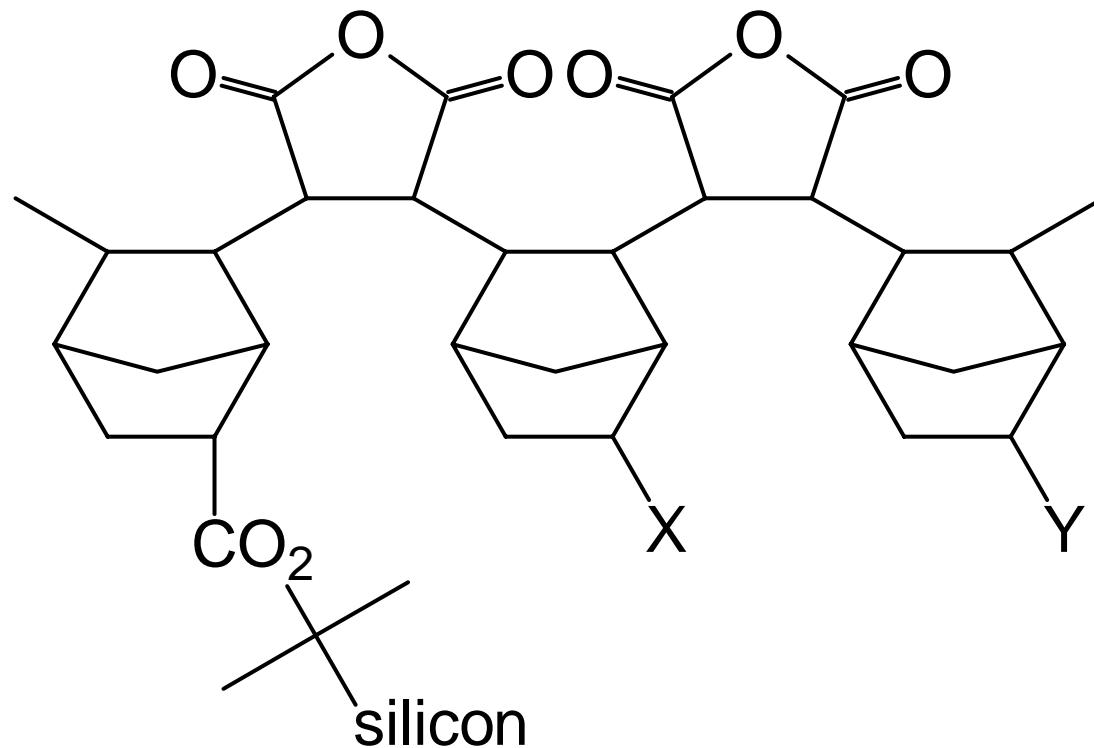
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<sup>c</sup> Intel Corporation, MS SC1-03, Santa Clara, CA 95052



# **Si-Bilayer Polymer C - “PRC”**

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**10-15% silicon  
good etch-stop properties  
*SPIE 1999***

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# PRC EUV Status - 3/99

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100 nm L/S

on MX-P7

PAB = 140 °C, 60 sec

dose = 5 mJ/cm<sup>2</sup>

PEB = 140 °C, 60 sec

development = LDD-26W, 60 sec

**Table 1.** Lithographic performance of **PRC-3** at EUV  
Resolution

CD Dose	DOF (1.1)	1:1 lines	1:2 lines	iso lines
5 mJ/cm <sup>2</sup>	1.5 μm	100 nm	70 nm	80 nm

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# **PRC Performance Improvement**

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**Better polymer solubility properties**

increase  $R_{\max}$ , decrease  $R_{\min}$

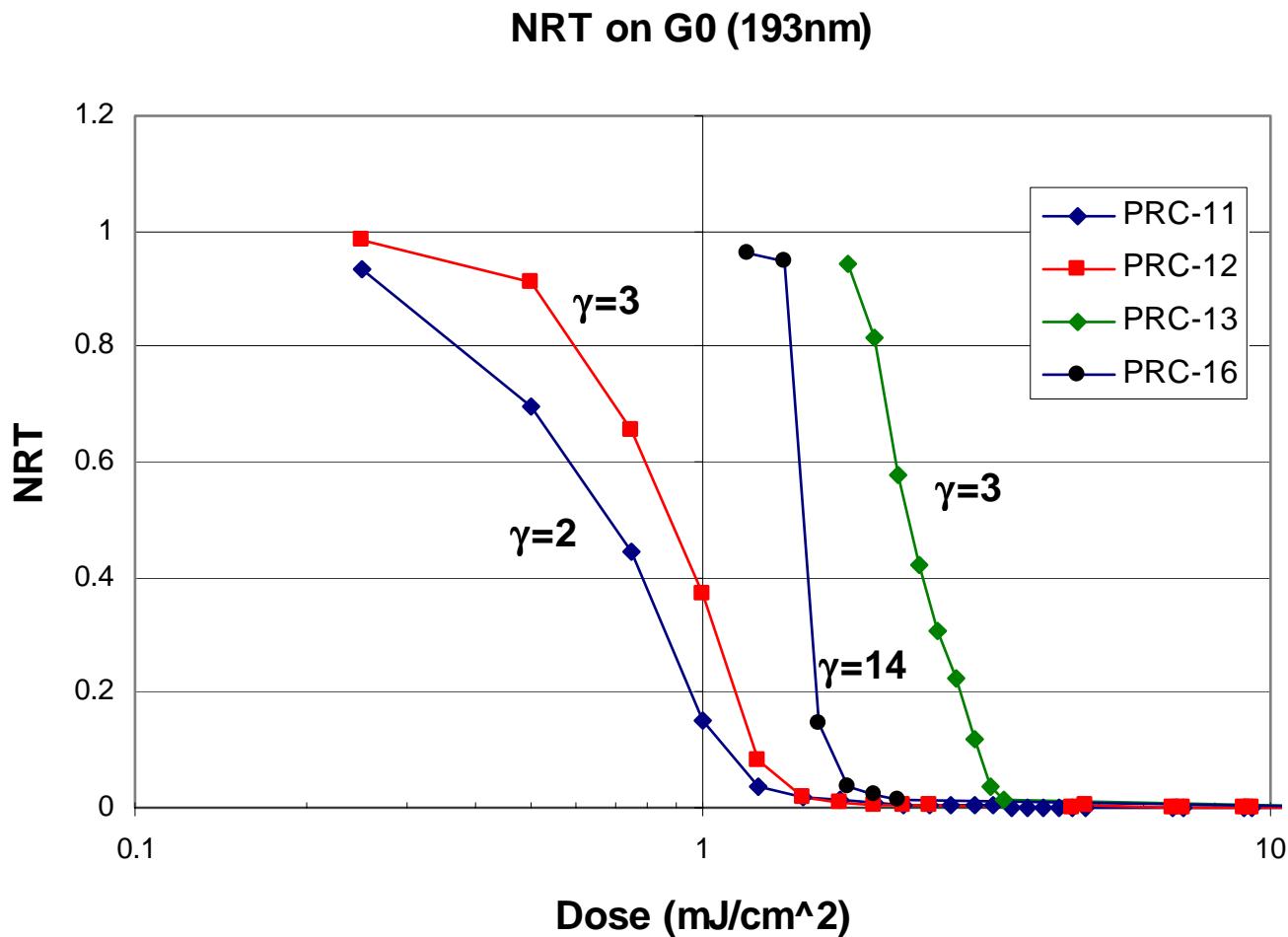
**Improved formulation**

dissolution inhibitors  
stabilizers

**Imaging layer/underlayer interface optimization**

control interface inhibition  
promote adhesion

# 193 nm Contrast Improvement

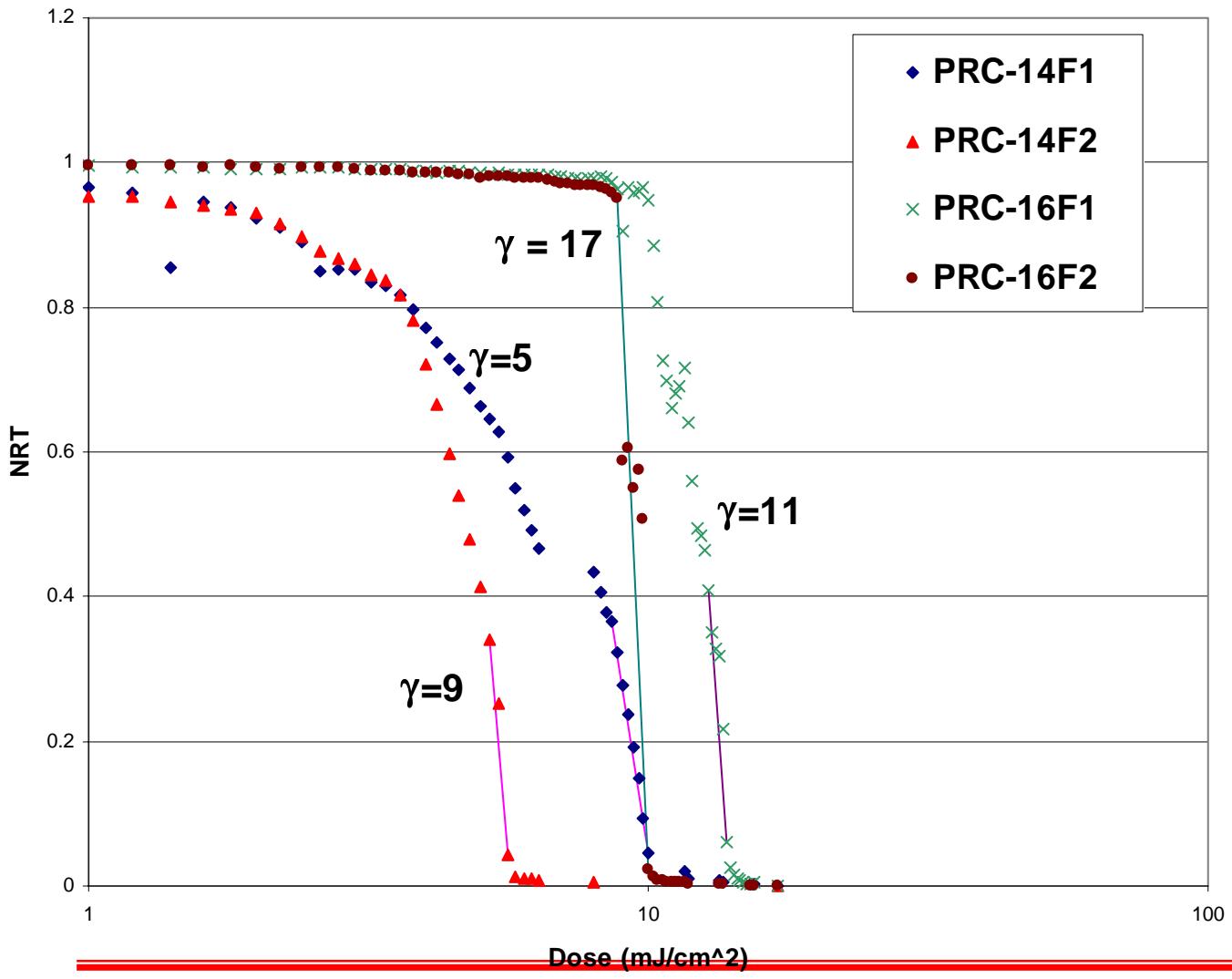


Increasing the base polymer solubility results in higher contrast

Underlayer G0  
Sematech RTC

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# PRC Contrast - 248 nm

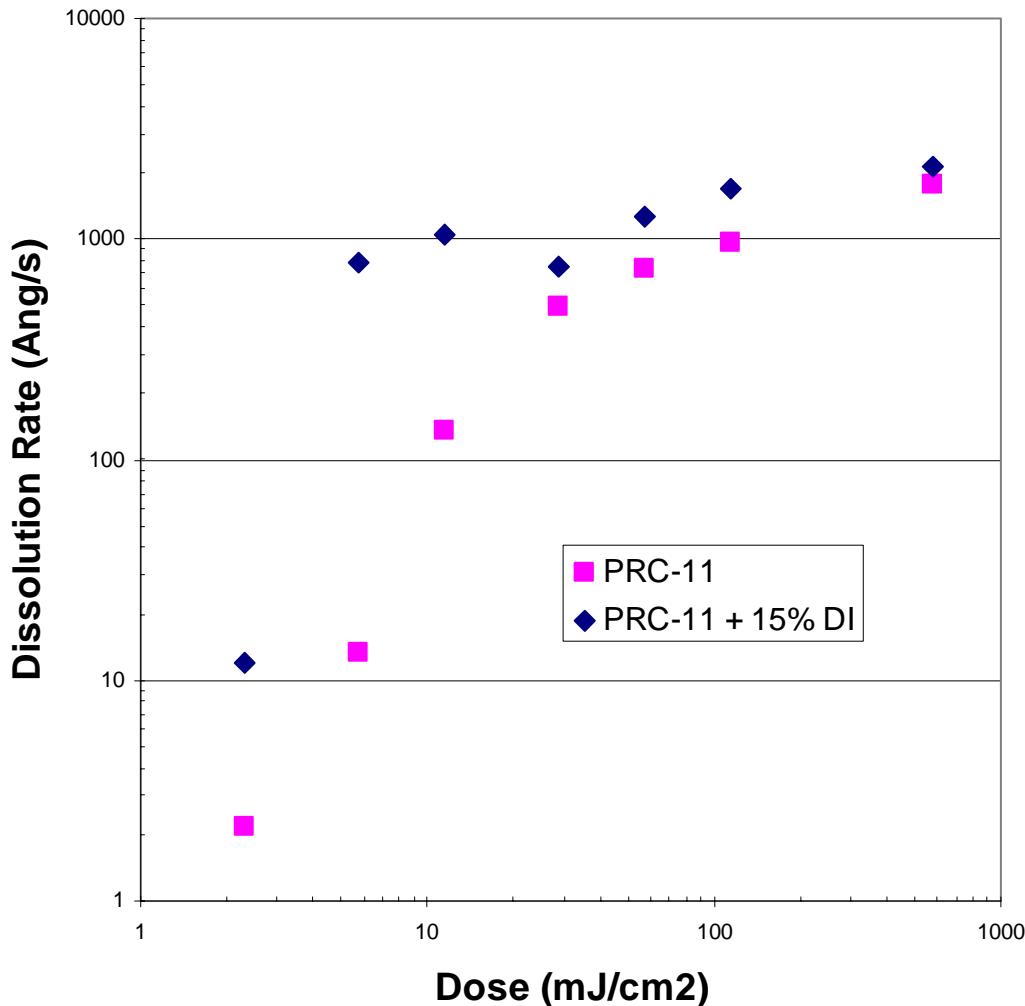


Contrast at 248 nm is even better, with none of the footing seen at 193 nm

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# PRC Dissolution Rate

Dissolution Rate vs. Dose (248nm)



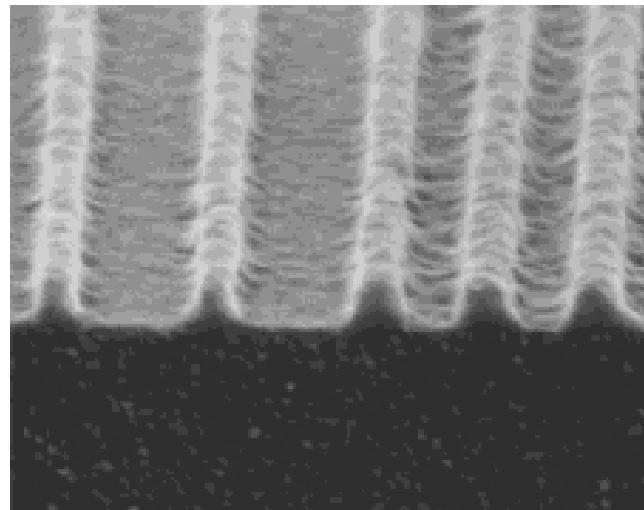
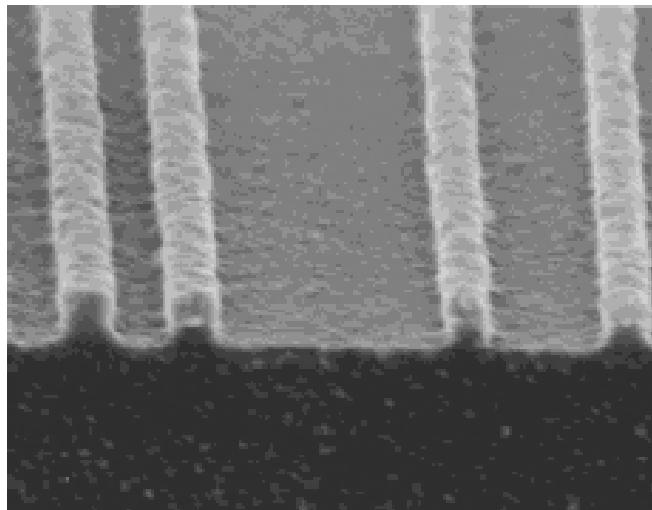
Polymer structure has  
been varied to  
increase Rmax

<u>Formulation</u>	<u>Rmax</u>
PRC-11 (no DI)	1782
PRC-12 (no DI)	1975
PRC-12 (+15%DI)	3551
PRC-14 (No DI)	3767
PRC-16 (No DI)	7576
PRC-16 (15% DI)	>7576

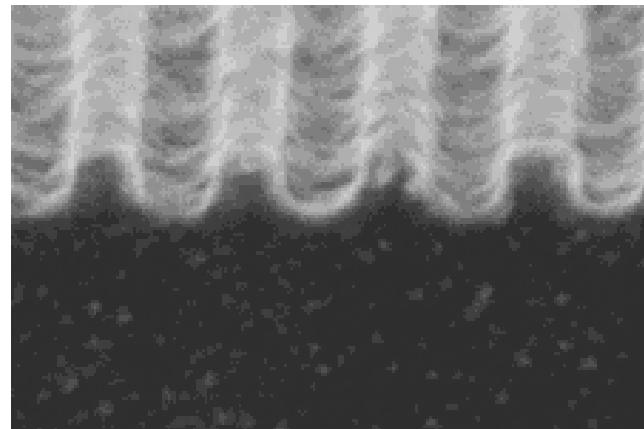
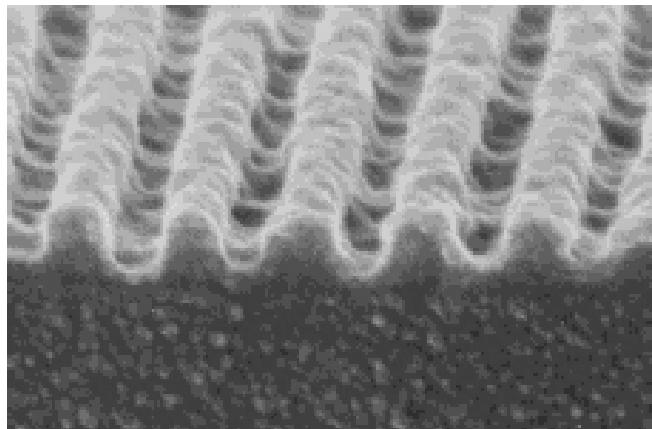
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# PRC-12 Scumming - EUV

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100 nm



80 nm

PRC-12 no DI

PRC-12 + DI

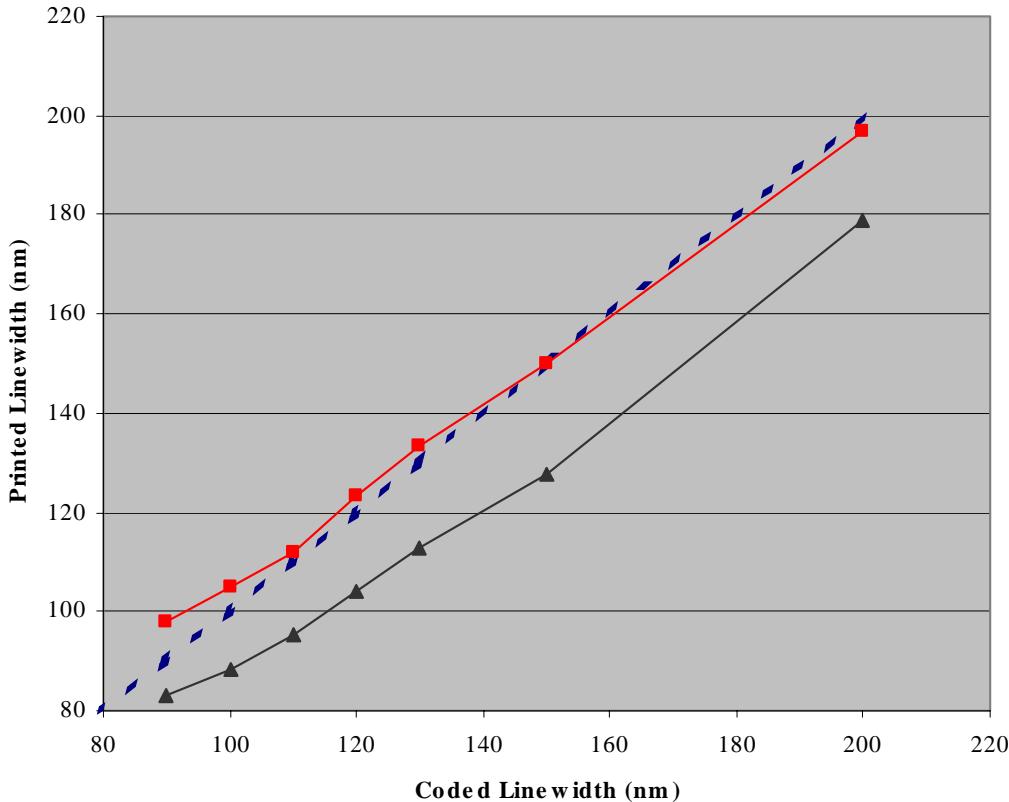
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# PRC-12 Linewidth

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Printed Linewidth versus Coded Linewidth



At EUV, PRC-12 shows good CD linearity with and without dissolution inhibitor.

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# EUV Status - PRC-12 8/99

Table 2 - Basic EUV Lithographic Results Summary

Resist	Reference No.	Thickness <sup>1</sup> (Å)	Unexposed Resist Loss (Å)	Dose <sup>2</sup>	Minimum 1:1 L/S Resolution (nm)	LER at Min. Res. (nm, 3σ)
PRC-12F1	990812b_1	~ 1000	~ 0	7.2	90	10.4
PRC-12F2	990812a_1	~1000	~ 0	7.2	90	12.2

Table 3 -Other EUV Lithographic Results Summary

Resist	Reference No.	LER (nm, 3σ)			Average LER (100, 150, 200 nm) (nm, 3σ)
		100 nm L/S	150 nm L/S	200 nm L/S	
PRC-12F1	990812b_1	8.6	7.4	6.2	7.4
PRC-12F2	990812a_1	11.3	9.9	11.4	10.9

# **Underlayers**

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**MX-P7 (MicroChem) - prior baseline**

**New underlayers being investigated**

**G0 (193 BARC)**

UL A	}	
UL B	}	crosslinked organic
UL C	}	polymers
UL D	}	3 distinct chemistries

**Also:** underlayer surface chemistry  
underlayer additives

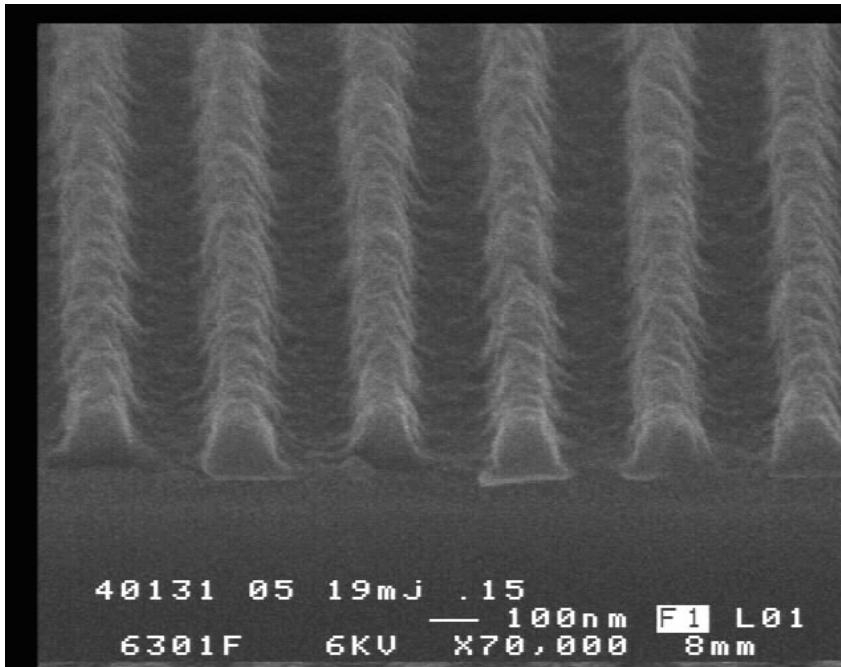
**Status:** significant difference in scumming seen  
differences not consistent across  $\lambda$  (?)

# **Underlayer Effect - PRC-12 248nm**

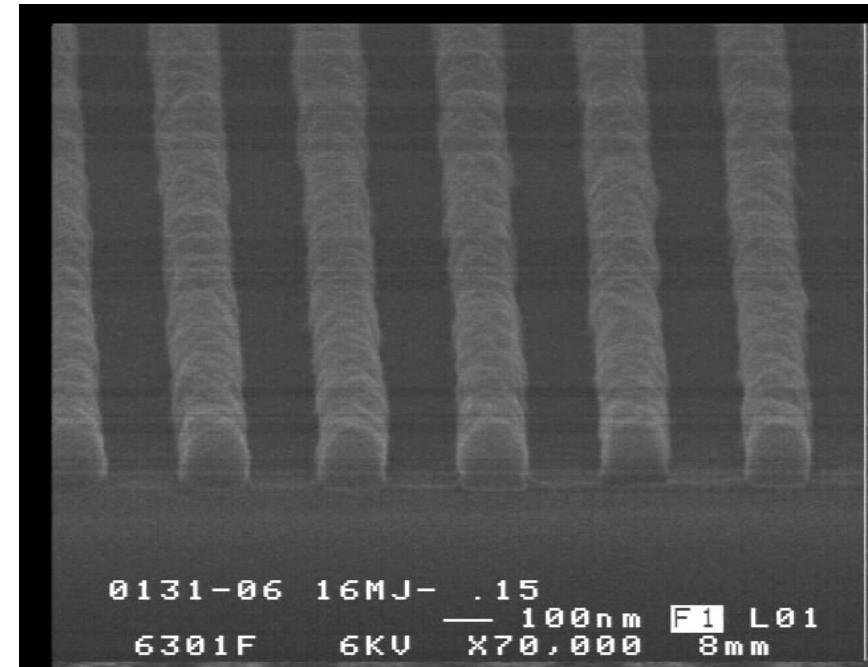
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Scumming can depend strongly on underlayer chemistry

**PRC-12 with dissolution inhibitor**



**Underlayer A**



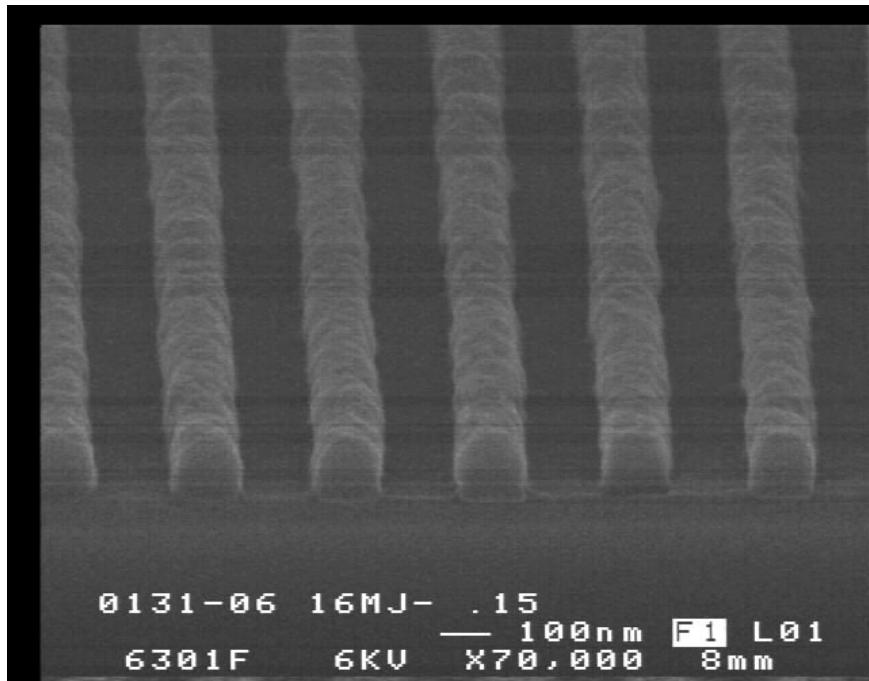
**Underlayer B**

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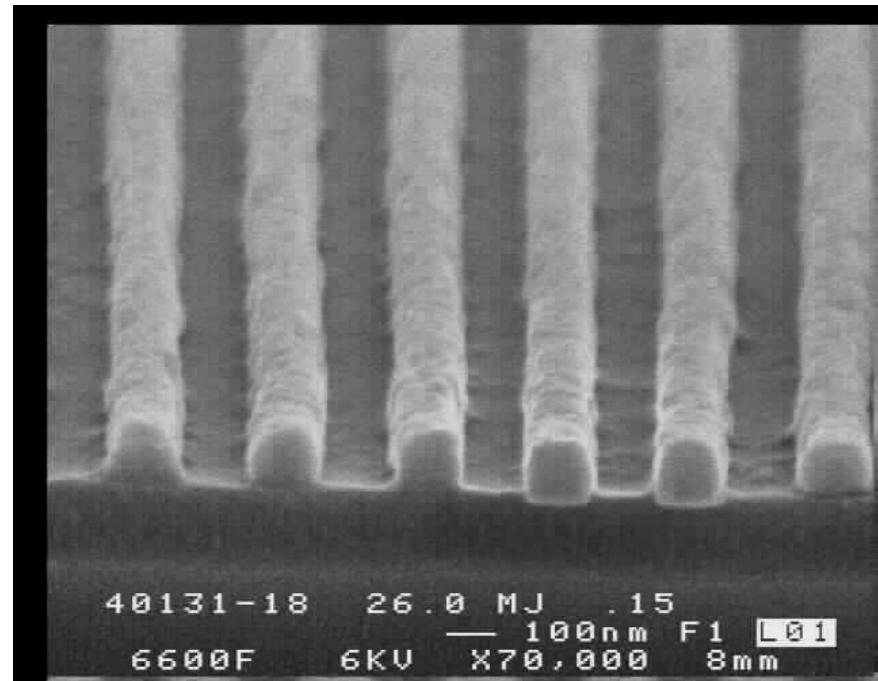
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# PRC-12/PRC-16 Comparison - 248 nm

Underlayer A, 248nm exposure with dissolution inhibitor  
Not the expected improvement!



PRC-12



PRC-16

PRC-16 EUV results in progress

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# **Continued Optimization**

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## **Polymer Solubility Optimization**

**MW control  
functionality ratios**

## **Formulation Optimization**

**stabilizers  
optical density**

## **Underlayer Optimization**

**underlayer surface chemistry  
adhesion  
etch properties**